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Research Article

An Introduction to the Pico-chemistry Working Hypothesis

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Abstract

The nuclear signatures that can be expected when contacting hydrogen with nickel were derived from thermal results recently obtained (Rossi energy amplifier), using the type of reaction paths proposed as the explanation of the energy produced. The consequences of either proton or neutron capture have been studied. It was shown that these consequences are not in line with the experimental observations. A novel tentative explanation is thus described. Should this explanation be true? It is proposed to call pico-chemistry the novel field thus opened.

Keywords: Enthalpie of formation, Hydrogen, Nickel, Nickel hydride, Nickel pico-hydride

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1. Introduction

This paper is an improved version of the paper “Is the Rossi energy amplifier the first pico-chemical reactor" published July 18TH 2010 in the “*Journal of Nuclear Physics*"

In a recent paper [1], it was shown that, if the reaction path occurring in a Rossi energy amplifier [2] was mainly proton capture, the lead thickness required to completely suppress the gamma flux produced would be of the order of tens of centimeters. The lead screen used (2 cm) should thus have resulted in a lethal gamma dose emitted in the surroundings. Another explanation different from either proton or neutron capture is to be found. In [3], the concept of pico-chemistry was presented which could explain the generation of photons in the range of tens of keVs, thus compatible with the lead screening used in the energy amplifier.

In chemistry, compounds are formed by the binding of the components through their outer electronic shells. Ionic, metallic and covalent hydrides of metals are known. Thus, nickel hydride NiH can be viewed as hydrogen and nickel atoms maintained at few angstroms distance from a metallic bound.

In contrast, in a pico-nickel hydride, a (shrunken) hydrogen atom would be inside the electronic shells of nickel and bound to the nickel at close proximity of its nucleus. In [3], a tentative explanation was given to the possibility of such an exotic hydride. A different approach is presented in this paper.

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2. Possible Existence of a Small Hydrogen-like Dipole and Reaction with a Nickel Nucleus

Various concepts of shrunken hydrogen atom have been presented. In [4], the possibility of having bound states of a proton and an electron with lower radius and higher ionization energy than the usual Bohr values is claimed. These bound states were called hydrinos and attributed to the possibility of having fractional values for the main quantum number of the hydrogen atom. In [5] a metastable state is justified by the electron spin/proton nuclear spin interaction being first order in the environment of a lattice (it is third order in vacuum). This state was called hydrex and proposed as an explanation for fission-like reaction occurring in metallic lattices. Finally, the interaction of a proton and an electron could result in a virtual neutron [6], that could be captured by and react with the Ni nucleus.

In this paper, the evolution of an electrical dipole formed between a proton adsorbed at the surface of a nickel (metal) particle in contact with a low work function substance and of an electron extracted from this substance is examined.

At the surface of various materials (metals, metal oxides, metal hydrides…), electrons are more or less easily extracted from this material. This is described by the work function of the material which is the minimum energy required to extract the electron from it. When a metallic particle is supported on a low work function substance, the amount of electrons able to be extracted from the supporting material by a positive charge is considerably increased, for a given temperature. In an hydrogen environment, were protons are trapped in the lattice of the metallic particle in surface sites, it is conceivable that from time to time such an electron of the low work function compound in contact with the metal, can be attracted by such a proton. Because this electron starts at rest from the low work function substance, which is at a distance of a few Angstrom from the metal in which the proton is adsorbed, it can go beyond the proton and penetrate deeply into the outer electronic shell of the metal atom. An electrical dipole with a sizeable charge separation (a small fraction of Angström depending upon the metal) is thus formed and is attracted by the nucleus of the atom. The overall electrical neutrality of the system metal/low work function substance is maintained because the metal having now a net negative charge, the metal electron in excess can neutralize the now positive low work function substance. It is a kind of electrical circuit as can be found for instance in Edison experiment. The formation of this type of dipole should be understood as a conjecture (working hypothesis): no such example can be found in the mainstream literature and most solid state physicists would not expect it to form.

One can wonder if the resulting effect of the action of the positive charge of the nucleus will ultimately end up in the destruction of the dipole, the proton being rejected to infinite and the electron bound to the nucleus of the metal. This would certainly be the case if the nucleus were not surrounded by its electronic shell (Ztime ionized nucleus). In the case of an atom with its electrons it is possible that the electron starts oscillating round the proton, resulting in a polarized ellipsoidal hydrogen like atom, the center of gravity of the electron cloud thus formed being at a distance d

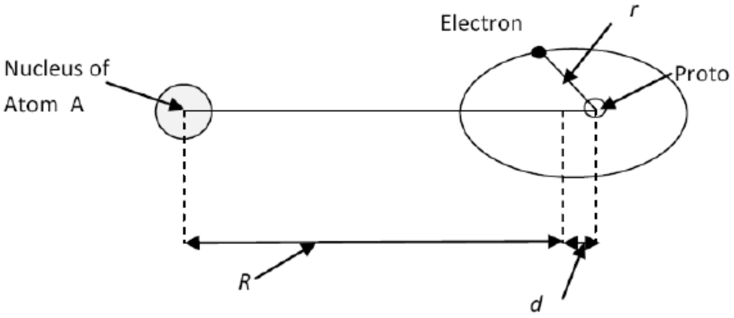

Figure 1. Description of the hypole.

from the proton, between the nucleus of the metal and the proton. This could result from the alternative repulsion by the inner electrons of the metal when the electron is between the proton and the metal nucleus and the attraction by the proton when it is on the other side. To demonstrate the possibility of such a bound state, the complete Hamiltonian of the system would have to be solved, which is not possible. A semi-empirical approach has thus been developed, to evaluate the orders of magnitude of the characteristics of such a polarized hydrogen like atom when it reaches the vicinity of the k electrons layer of the metal nucleus. This layer is likely to be a strong barrier, preventing the electron and thus the polarized hydrogen like atom, to further progress towards the metal nucleus. The orders of magnitude of these characteristics have been accessed by determining the dimensions of the object for which the potential and the kinetic energy are balanced (Bohr radius). They could be used as a guide when looking at the experimental results expected in case of an excess energy measured in systems hydrogen/metal (energy of radiations emitted, characteristics of the by-products…). In order to distinguish this concept of shrunken hydrogen atom from others, it is proposed to call it *Hypole (Deupole* and *Tripole* being the two other isotopes).

3. Semi-empiric Description of the Hypole

Figure 1 gives a description of the Hypole, which is proposed to be written $\overrightarrow{\mathrm{H}}_{\mathrm{Ni}}$ when the host atom A is nickel and its (possible) bound state with the Ni atom, a nickel pico-hydride $\mathrm{Ni}\overrightarrow{\mathrm{H}}_{\mathrm{Ni}}$. The electron is moving around the proton at a mean distance r and the center of gravity of the resulting electron cloud is close to the center of the proton, creating an electrical dipole. d is the distance between the center of gravity of the electron cloud and the center of the proton. r is the distance between the proton and the electron of the hypole. R is the distance between the center of the nucleus of the atom A and the electrical center of gravity of the hypole. Z is the charge number of the atom A .

The potential that the dipole proton/electron feels from the nucleus of A is at first order (when d/R is small):

$$\mathrm{V}= -\ Ze^2\left(\frac{1}{R}-\frac{1}{R+d}\right)\cong -Ze^2\frac{d}{R^2}.$$

The condition for the dipole to be stable is that the repulsive potential between the nickel nucleus and the proton is lower than the sum of the attractive potentials between the nickel nucleus and the electrical center of gravity of the hypole and between this center of gravity and the proton:

$$\frac{Z}{R}\leq\frac{Z}{r}+\frac{1}{d}.$$

This condition is met when d is small compared to R, with can be written $d = kR$ (k small and constant). The stability condition is then:

$$\frac{Z}{R}\leq\frac{Z}{r}+\frac{1}{kR}\quad\text{or}\quad\frac{kZ-1}{kr}\leq\frac{1}{kR}$$

This condition is thus met for $k\leq 1\big/Z$.

During its attraction by A, the spatial extension of the dipole is limited by the repulsion of the inner layers of the electrons of A, resulting in a shrinking of this hydrogen-like object and in a limitation of its polarization, when it cascades down towards the nucleus of A through its various electronic layers. In the vicinity of the k layer of A, the 2 s k electrons of A are a strong obstacle for further progression towards the nucleus. In order to get first estimated values of the size and energy of the final state of the hypole and of the bound state it might form with A, following assumptions are made.

(1) The action of the k electronic shell of A on the dipole and the presence at short distance of the Z protons of A are equivalent to the attraction of the electron by the proton in the hypole being multiplied by a factor K. The

electron oscillates round the proton and feels a strong repulsive potential of the k electrons of the nickel (Pauli exclusion principle resulting in a kind of Lennard-Jones potential) when between the proton and the nickel nucleus and the strong attraction of the proton and the nickel nucleus when on the other side. The object formed can be viewed as a reduced and ellipsoidal hydrogen like atom, the electrically negative electron cloud having a charge center of gravity slightly closer to the Nickel nucleus than the proton, at a small distance d from the proton. Hence, the (pseudo) coulomb interaction between the electron and the proton in the dipole is taken as: $v = Ke^2/r$.

(2) d is small and proportional to R. Hence, $d = kR$ with k small (note that the electron is not at this small distance, which would imply MeV energy levels). The parameter d describes the polarization of the hydrogen like hypole. The dimension of this hypole will be shown to be in the order of picometer thus implying keV energy levels for the localization of the electron involved in its formation.

(3) The electron of the hypole $\overrightarrow{\mathrm{H}}_{\mathrm{A}}$ cannot be found in the nucleus of the atom A (competition with the k layer s electrons of A resulting in a Lennard–Jones type of repulsive potential). Hence, $r \leq R$.

With assumption (1), the Bohr radius of $\overrightarrow{\mathrm{H}}_{\mathrm{A}}$ would be $r_{\overrightarrow{\mathrm{H}}_{\mathrm{A}}} = \hbar^2/m_{\mathrm{e}}Ke^2$ and its energy of formation $E_{\overrightarrow{\mathrm{H}}_{\mathrm{A}}} = m_{\mathrm{e}}K^2e^4/2\hbar^2$.With assumption (2), the potential between the dipole and A is

$$V = -\,Ze^2\left(\frac{1}{R}-\frac{1}{R+d}\right) \cong -Ze^2\frac{d}{R^2} \cong -Ze^2\frac{k}{R}$$

and thus Coulombic: the Bohr radius of $\mathrm{A}\overrightarrow{\mathrm{H}}_{\mathrm{A}}$ attracted by A would then be $R_{\mathrm{A}\overrightarrow{\mathrm{H}}_{\mathrm{A}}} = \hbar^2/m_{\mathrm{H}}KZe^2$ and its energy of formation $E_{\mathrm{A}\overrightarrow{\mathrm{H}}_{\mathrm{A}}} = m_{\mathrm{H}}K^2Z^2e^4/2\hbar^2$ with m_{H} being the mass of the hydrogen atom.

Under assumption (3), the smallest possible bound object $\mathrm{A}\overrightarrow{\mathrm{H}}_{\mathrm{A}}$ is obtained for $R = r$. In that case $m_{\mathrm{e}}K = m_{\mathrm{H}}KZ$. Expressing the energies as a function of the unknown k, one gets:

$$E_{\overrightarrow{\mathrm{H}}_{\mathrm{A}}} = \frac{e^4}{2\hbar^2}\frac{m_{\mathrm{H}}}{m_{\mathrm{e}}}m_{\mathrm{H}}k^2Z^2 \quad \text{and} \quad E_{\mathrm{A}\overrightarrow{\mathrm{H}}_{\mathrm{A}}} = \frac{e^4}{2\hbar^2}m_{\mathrm{H}}k^2Z^2$$

finally yielding the following value for the total energy given by the hypole formation followed by its binding with A: .

$$E_{\mathrm{T}} = E_{\overrightarrow{\mathrm{H}}_{\mathrm{A}}} + E_{\overrightarrow{\mathrm{H}}_{\mathrm{A}}} = \frac{e^4}{2\hbar^2}\left(m_{\mathrm{e}}k^2 + m_{\mathrm{H}}k^2Z^2\right) = \frac{e^4}{2\hbar^2}m_{\mathrm{H}}k^2Z^2\left(1+\frac{m_{\mathrm{H}}}{m_{\mathrm{e}}}\right).$$

The bulk of the energy is coming from the formation of the Hypole. $E_{\overrightarrow{\mathrm{H}}_{\mathrm{A}}}$ is likely to be of the order of magnitude of the energies that can be found close to the A nucleus, that is the K layer $s$electrons energy $E_{\mathrm{A}}^{\mathrm{sK}}$ as a first approximation. A guesstimated value of the order of magnitude of k is thus:

$$k = \frac{1}{Z}\sqrt{E_{\mathrm{A}}^{\mathrm{sK}}\frac{2\hbar^2}{m_{\mathrm{H}}e^4}\frac{m_{\mathrm{e}}}{m_{\mathrm{H}}}}.$$

In the case of nickel and taking for $E_{\mathrm{A}}^{\mathrm{sK}}$ the average value 10.5 keV , the the following guesstimated description of $\overrightarrow{\mathrm{H}}_{\mathrm{Ni}}$ and $\mathrm{Ni}\overrightarrow{\mathrm{H}}_{\mathrm{Ni}}$ is obtained (Table 1).

It should be noted that a charge separation (1 fm) for a dipole formed by a proton and an electron, would involve several hundred MeV of localization energy and this point will need to be addressed at some point in the future.

It should also be noted that solving the radial Schrödinger equation for the $1/r^2$ interaction for a dipole (i.e. not Coulombic as proposed) would give an hypole energy of formation of some 55 keV, not in very good agreement with the

Table 1. Nickel hypole and nickel pico-hydride energies of formation.

Hypole dimension $R = r$ (fm)	Hypole charges separation d (fm)	Hypole energy o formation (eV)	Ni pico-hydride energy of formation (eV)	Apparent Coulomb interaction K	Charges separation factor k
1906	1.03	10500	5.7	27.8	5.4×10^{-4}

energy found (10,5 keV) and a proton localization much closer to the nickel nucleus than obtained above (this resulting in an even more localized electron).

4. Properties of the Hypole

The hypole is a picometer size hydrogen-like object. It can only exist when embedded in the electronic shell of an atom A, where its equilibrium position is very close to the nucleus of A. Its size and energy of formation depends upon A. In the case of nickel, the size is some 2 pm and the energy of formation round 10 keV. Hence the names and notations proposed.

The best way for characterizing a hypole is to measure the mass of the corresponding A/pico-hydride. In the case of nickel, following masses are expected, that take into account the energy of formation (Table 2):

The mass differences given by Table 2 could be easily detected using a high-resolution TOF Mass Spectrometer on an acidic solution of the nickel pico-hydride (probably possible see below, chemical properties). SIMS TOF Mass Spectrometry is not adapted, since the primary ions energies are of the order of the energy of formation of the hypole. An ICP TOF Mass Spectrometer would be adapted. The modifications of the electronic shell of the atom A (nickel in that case) could be evidenced using EDS-X analysis. X-ray emission during the formation of the hypole should also be observed (energy lower or equal to 10.3 keV in the case of nickel).

As regards the chemical properties of $\mathrm{Ni}\overrightarrow{\mathrm{H}}_{\mathrm{Ni}}$, they should be close to the nickel ones. The outer electronic layers of $\mathrm{Ni}\overrightarrow{\mathrm{H}}_{\mathrm{Ni}}$ indeed see the positive charge of the nickel atom, the effect of the hypole $\overrightarrow{\mathrm{H}}_{\mathrm{Ni}}$ being second order in that respect. A shift of the characteristic rays given by nickel in ICP-AOS could be observed. Finally the radiations emitted during the hypole formation, would be photons in the 10 keV range, thus completely suppressed by the 2 cm layer of lead in the energy amplifier. Faint signals of higher energy photons (annihilation radiation) could anyhow be detected. They might be the signature of an inherent instability of the hypole and of the corresponding pico-hydride, which is discussed now.

Table 2. Nickel pico-hydrides masses.

Ni parent composition (x_i)	Ni parent nucleus	Mass of parent Ni nucleus	Mass of Ni pico-hydride	Mass of the closest stable atom	The closest stable atom	Mass difference (ppm)
0.68007	^{58}Ni	57.935346	58.943152	58.933198	^{59}Co	169
0.26223	^{60}Ni	59.930788	60.938594	60.931058	^{61}Ni	124
0.0114	^{61}Ni	60.931058	61.938864	61.928346	^{62}Ni	170
0.03634	^{62}Ni	61.928346	62.936152	62.929598	^{63}Cu	104
0.0926	^{64}Ni	63.927968	64.935774	64.927793	^{65}Cu	123

5. Stability of the (Nickel) Hypole

The nickel hypole is a small object of picometer dimension and at picometer distance from the nickel nucleus. Its virtual neutron state may have a non-zero probability to penetrate the nickel nucleus and react with it according to the neutron capture route developed in [6,1]. Most of the gamma photons resulting from the stabilization of the primary excited nickel nuclei are of energy higher than 1 MeV [1]. They mainly interact with the lead shield by producing electron/positron pairs, ultimately yielding the annihilation radiation. From the experimental observations, the rate of virtual neutron capture should be very low (some $10^{-10}\,\mathrm{s}^{-1}$, in the experiment 2009 (3–5/4–26) presented in [2]).

6. Discussion

The model described in this paper should be viewed as a working hypothesis aimed at guiding the experiments. It could be validated by the above-predicted characteristics of the reaction products.

Finally, one might wonder what would be the impact, if true, of the pico-chemistry on other known NiH system. Indeed, abnormal heat release could already have been observed in catalysis for instance. But commercial catalysts are very seldom prepared with carriers having a low work function and according to the pico-chemistry no abnormal heat production should be observed when using them.

7. Conclusions

In this paper, a rough description is given, of a possible novel chemical interaction. Orders of magnitudes of the main characteristics of this still hypothetical interaction are given. It is hoped that this approach will be of help when trying to understand the thermal results obtained in certain Ni/H (or other metal/H) systems. Should the experimental results and their interpretation be true, the pico-chemistry working hypothesis could be accepted as an explanation of the experimental data.

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